UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2015

Module Number: EE8261 **Module Name: Intelligent Systems Engineering**

[Three Hours]

[Answer all questions, each question carries **10 marks]**

Q1 a) Given the fuzzy sets,

$$\text{Tall}(X) = \begin{cases} 0 & \text{if } X < 1.6\text{m} \\ (X - 1.6\text{m}) / 0.2 & \text{if } 1.6\text{m} <= X < 1.8\text{m} \\ 1 & \text{if } X >= 1.8\text{m} \end{cases}$$

$$\text{Short}(X) = \begin{cases} 1 & \text{if } X < 1.6\text{m} \\ (1.8\text{m} - X) / 0.2 & \text{if } 1.6\text{m} <= X < 1.8\text{m} \\ 0 & \text{if } X >= 1.8\text{m} \end{cases}$$

i) Sketch the graphs of Tall(X) and Short(X).

ii) Calculate the Union of the fuzzy sets Tall(X) and Short(X).

iii) Calculate the Intersection of the fuzzy sets Tall(X) and Short(X).

iv) Show that the complement of Tall(X) is Short(X).

[6 Marks]

b) Given additional fuzzy sets:-

$$\text{Strong}(Y) = \begin{cases} 0 & \text{if } Y < 30\text{kg} \\ (Y - 30\text{kg}) / 20 & \text{if } 30\text{kg} <= Y < 50\text{kg} \\ 1 & \text{if } Y >= 50\text{kg} \end{cases}$$

$$\text{Weak}(Y) = \begin{cases} 1 & \text{if } Y < 30\text{kg} \\ (50\text{kg} - Y) / 20 & \text{if } 30\text{kg} <= Y < 50\text{kg} \\ 0 & \text{if } Y >= 50\text{kg} \end{cases}$$

and the fuzzy rules:-

If Tall(X) OR Strong(Y) then Heavy(Z)

If Short(X) AND Weak(Y) then Light(Z)

Calculate the membership values of Heavy(Z) and Light(Z) where ,

i) X = 1.65m, Y = 30kg

ii) X = 1.70m, Y = 45kg

[4 Marks]

Q2 A pizza chain wants to open its delivery centers across the Galle city. They need to analyze the areas from where pizzas are ordered frequently.

They need to understand as to how many pizza stores have to be opened to cover delivery in the area. They need to figure out the locations for the pizza stores within all these areas in order to keep the distance between the store and delivery points minimum.

a) Briefly explain unsupervised learning.

[2 Marks]

b) Explain what the k-means clustering algorithm is. You do not need to write code, but give a precise written description which someone could turn into code.

[3 Marks]

c) i.) State two features that you need to address the above problem.

[2 Marks]

ii) Explain how to figure out the locations for the new pizza stores with the k-means algorithm.

[3 Marks]

Q3 a) Briefly explain supervised learning.

[2 Marks]

b) Explain what the KNN algorithm is. You do not need to write code, but give a precise written description which someone could turn into code.

[3 Marks]

c) We have data from the questionnaires survey (to ask people's opinions) and objective testing with two attributes (acid durability and strength) to classify whether a special paper tissue is good or not. The four training samples are presented in Table Q3.

Table Q3

X_1 = Acid Durability (seconds)	X_2 = Strength (kg/square meter)	
7	7	Bad
7	4	Bad
3	4	Good
1	4	Good

Now the factory produces a new paper tissue that passes the laboratory test with $X_1 = 3$ and $X_2 = 7$.

Suppose K = 3.

i) Calculate the distance between the query-instance (3, 7) and all the training samples.

[2 Marks]

ii) Sort the distance and determine nearest neighbors based on the K-th minimum distance

[1 Mark]

iii) State the category Y of the nearest neighbors.

[1 Mark]

iv) Predict whether the paper is good or bad.
[Hint: Use simple majority of the category of nearest neighbors as the prediction value of the query instance.]

[1 Mark]

Q4 a) Below you will see some real world information about a family. You can use this information to place facts in the file that describe the family.

John is the parent of Rob, Andy and Claire.
Mary is the parent of Rob, Andy and Claire.
Mary and Claire are female.
Rob, Andy and John are male.

i) Write a Prolog database for the above family. The database consists of ground atomic formulas made from the predicates.
Example: male().
female()
parent()

[2 Marks]

ii) Further, you have the following recursive definition of "ancestor":
ancestor(X,X).
ancestor(X,Z) :- parent(X,Y), ancestor(Y,Z)
What answers does Prolog return ?ancestor(X,Y) and in what order?

[2 Marks]

b) In mechanics, the energy of a moving body is called kinetic energy. If an object of mass ***m*** (kilograms) is moving with a velocity ***v*** (meters per second), the kinetic energy is given by $K = \frac{1}{2} mv^2$. Suppose we model the mass and velocity as inputs to a system (moving body) and the energy as output, then observe the system for a while and deduce the following two rules of inference based on our observations:

Rule 1:
IF x_1 is small mass and x_2 is high velocity , THEN y is medium energy

Rule 2 :
IF x_1 is large mass or x_2 is medium velocity, THEN y is high energy.

Let input
(i)= 0.35 kg (mass) and input (j) = 55 m/s (velocity), Find the output using a Mamdani implication (use Centroid method for defuzzification)

[6 Marks]

Q5 a) Briefly explain how to perform cost function for uninvarient linear regression. Give a precise description with equations.

[2 Marks]

b) Explain how to minimize cost function j with gradient descent algorithm. You do not need to write code, but give a precise written description with equations and graphs which someone could turn into code.

[2 Marks]

c) Explain how you can perform Gradient descent algorithm for multiple variables. You do not need to write code, but give a precise verbal description with equations.

[1 Marks]

d) Sketch a graph of θ_1 and θ_2 without scaling. Assume the worst case scenario.

[1Marks]

e) Provide equation to scale data.

[1 Marks]

f) Sketch a graph of $\theta 1$ and θ_2 with scaling.

[1 Marks]

g) Briefly explain what would happen when learning rate is too large and too small.

[2 Marks]